VARIABLE DISPLACEMENT MECHANISM FOR SCROLL TYPE COMPRESSOR

BACKGROUND OF THE INVENTION

The present invention relates to a scroll type compressor for use in a vehicle air conditioner and more particularly to a variable displacement mechanism for varying the displacement of the scroll type compressor.

A variable displacement mechanism of such type is disclosed in Japanese Unexamined Patent Publication No. 2001-32787. A compression chamber communicates with a suction pressure region through a by-pass passage in a process of volume reduction. A spool valve opens and closes the by-pass passage to vary the displacement of the scroll type compressor.

In the spool valve, a spool is slidably accommodated in a cylinder. The spool includes a valve portion and a rod portion. The valve portion has an outer diameter that is substantially equal to an inner diameter of the cylinder. Also, the valve portion opens and closes the by-pass passage. The rod portion has an outer diameter that is smaller than the inner diameter of the cylinder, and partially constitutes the by-pass passage.

However, in the variable displacement, the spool is formed to open and close a port that is open at an inner circumferential surface of the cylinder (an inner surface of the cylinder) by the valve portion (a column) of the spool so that it is difficult to arrange a seal member at the valve portion. Therefore, the valve portion of the spool contacts the inner circumferential surface of the cylinder so as to prevent refrigerant gas from leaking from the spool valve.

A small clearance between the valve portion of the spool and the inner circumferential surface of the cylinder effectively suppresses the leakage of the refrigerant gas from the by-pass passage. However, as the clearance between the valve portion of the spool and the inner circumferential surface of the cylinder is relatively small, sliding resistance increases between the spool and the cylinder. As a result, problems, such as deterioration in response to displacement variation and enlargement of an actuator for actuating the spool, occur.

Accordingly, in a prior art, in view of suppressing the rise of cost for manufacturing a highly accurate clearance, the clearance between the valve portion of the spool and the inner circumferential surface of the cylinder is relatively large. Then, for example, even though the scroll type compressor is tried to operate at a maximum displacement by closing the by-pass passage, a desired maximum displacement cannot be achieved due to the leakage of the refrigerant gas from the spool (the by-pass passage). Namely, performance of the

scroll type compressor deteriorates.

SUMMARY OF THE INVENTION

The present invention provides a variable displacement mechanism that reliably seals a by-pass passage for a scroll type compressor.

In accordance with the present invention, in a scroll type compressor having a movable scroll member and a fixed scroll member, the movable scroll member and the fixed scroll member define compression chambers therebetween. The compression chambers reduce in volume as the compression chambers are moved radially and inwardly by orbiting the movable scroll member relative to the fixed scroll member. Thus gas is compressed. A suction pressure region is defined in the scroll type compressor. A variable displacement mechanism for the scroll type compressor includes a by-pass passage, a valve chamber, a valve plate and an actuator. The by-pass passage serves to interconnect the compression chamber in a process of volume reduction with the suction pressure region includes a first valve hole. The valve chamber serves to communicate with the first valve hole and forms a valve seat surface around an opening of the first valve hole. The valve plate has an end surface that faces the valve seat surface. The valve plate is arranged in the valve chamber so as to selectively move between an open position, where the end surface is separated

from the valve seat surface to open the first valve hole, and a close position, where the end surface contacts the valve seat surface to close the first valve hole. An actuator serves to actuate the valve plate.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. 1 is a longitudinal cross-sectional view of a hybrid compressor according to a preferred embodiment of the present invention;

FIG. 2 is a cross-sectional view of the hybrid compressor taken along the line I - I in FIG. 1;

FIG. 3A is a partially enlarged cross-sectional view that corresponds to FIG. 1 in a state where a valve plate is located at an open position; and

FIG. 3B is a partially enlarged cross-sectional view that corresponds to

FIG. 1 in a state where the valve plate is located at a close position.

DETAILED DESCRIPTION OF THE PREFERRED EMDODIMENT

A preferred embodiment according to the present invention will be described. The preferred embodiment applies the present invention to a hybrid compressor C that is a scroll type. The left and right sides of FIG. 1 respectively correspond to the front and rear sides the compressor C.

The compressor C will be schematically described. As shown in FIG. 1, the compressor C constitutes a refrigerating cycle of a vehicle air conditioner and includes a housing 11, a compression mechanism 12, an electric motor 21 and a power transmission mechanism 22. The compression mechanism 12 and the electric motor 21 are accommodated in the housing 11. The power transmission mechanism 22 is arranged on an outer wall of the housing 11. The compression mechanism 12 is a scroll type and has a structure to vary a displacement of the compressor C. The power transmission mechanism 22 receives power from an engine (internal combustion) E for traveling a vehicle.

The compressor C is selectively driven by one of power from the engine E through the power transmission mechanism 22 and power from the electric motor 21. Since the compressor C includes the electric motor 21, air conditioning

(cooling) is capable of being continuously conducted even when the engine E is in a stopped state. Therefore, the vehicle air conditioner in the present preferred embodiment is particularly suitable for an idle stop vehicle and a hybrid vehicle.

The compressor C will be now described in detail. As shown in FIG. 1, the housing 11 includes a casing 11a and a cover 11b. The casing 11a has a cylindrical shape with a bottom that corresponds to the front side. The cover 11b is fixed to the rear end of the casing 11a. A rotary shaft 13 is rotatably arranged in the housing 11. A through hole 34 is formed at the center of the bottom of the casing 11a of the housing 11 so as to extend therethrough. The front end of the rotary shaft 13 is interposed into the through hole 34. The front end of the rotary shaft 13 is rotatably supported by the housing 11 through a bearing 35 in the through hole 34. A lip seal 37 is arranged on the front end of the rotary shaft 13 in the housing 11 for sealing the rotary shaft 13.

A shaft support member 31 is fixed on the rear end side of the casing 11a in the housing 11. A through hole 31a is formed at the center of the shaft support member 31 so as to extend therethrough. The rear end of the rotary shaft 13 is interposed into the through hole 31a of the shaft support member 31 and is rotatably supported by the shaft support member 31 through a bearing 32 in the through hole 31a.

The power transmission mechanism 22 includes a pulley 17 and an electromagnetic clutch 18. The pulley 17 is rotatably supported at the outside of the housing 11 and transmits the power from the engine E to the rotary shaft 13. When the electromagnetic clutch 18 is switched on (energized), the electromagnetic clutch 18 permits power transmission from the pulley 17 to the rotary shaft 13. When the electromagnetic clutch 18 is switched off (de-energized), the electromagnetic clutch 18 blocks the power transmission.

A stator 15 is provided on the inner circumferential surface of the casing 11a of the housing 11 and is located on the front side of the housing 11. A rotor 14 is fixed to the rotary shaft 13 in the housing 11 so as to be located inside the stator 15. The electric motor 21 includes the stator 15 and the rotor 14. The electric motor 21 integrally rotates the rotor 14 and the rotary shaft 13 by supplying electric power to the stator 15.

A fixed scroll member 41 is fixedly accommodated at the opening end of the casing 11a in the housing 11. The fixed scroll member 41 includes a fixed base plate 61 that has a disc-shape, an outer circumferential wall 62 that has a cylindrical shape and a fixed spiral wall 63. The outer circumferential wall 62 extends from the outer periphery of the fixed base plate 61. The fixed spiral wall 63 extends from the fixed base plate 61 inside the outer circumferential wall 62. The end surface of the outer circumferential wall 62 is joined to the rear surface of

the shaft support member 31.

A crankshaft 43 is provided at the rear end surface of the rotary shaft 13 and is offset from an axis L of the rotary shaft 13 in an eccentric direction. The crankshaft 43 is inserted in a bushing 51. A movable scroll member 42 is supported by the bushing 51 through a bearing 52 so as to face the fixed scroll member 41 and so as to rotate relative to the fixed scroll member 41. The movable scroll member 42 includes a movable base plate 65 that has a disc-shape and a movable spiral wall 66 that extends from the movable base plate 65 toward the fixed scroll member 41.

The movable spiral wall 66 of the movable scroll member 42 is engaged with the fixed spiral wall 63 of the fixed scroll member 41. The end surfaces of the fixed and movable spiral wall 63 and 66 respectively contact the movable and fixed base plates 65 and 61. Therefore, the fixed base plate 61 and the fixed spiral wall 63 of the fixed scroll member 41 and the movable base plate 65 and the movable spiral wall 66 of the movable scroll member 42 define compression chambers 67.

A self-rotation preventing mechanism 68 is arranged between the movable base plate 65 of the movable scroll member 42 and the shaft support member 31. The self-rotation preventing mechanism 68 is constituted of a

plurality of cylindrical recesses 68a and a plurality of pins 68b. The cylindrical recesses 68a are formed at the back surface (the front surface) of the movable base plate 65. The pins 68b are mounted on the rear end surface of the shaft support member 31 and is loosely fitted in the corresponding cylindrical recesses 68a.

A suction chamber 69 or a suction pressure region is defined between the outer circumferential wall 62 of the fixed scroll member 41 and the outer circumferential portion of the movable spiral wall 66 of the movable scroll member 42. An inlet 50 is formed in the outer circumferential wall of the casing 11a of the housing 11 so as to correspond to an accommodating space for the electric motor 21. An external conduit is connected to the inlet 50 and leads to a heat exchanger on a low-pressure side in an external refrigerating circuit (not shown). A suction passage 39 is formed in the outer circumferential portion of the shaft support member 31 in the housing 11 for interconnecting the accommodating space for the electric motor 21 with the suction chamber 69. Therefore, low-pressure refrigerant gas from the external refrigerating circuit is introduced into the suction chamber 69 through the inlet 50, the accommodating space for the electric motor 21 and the suction passage 39. The suction refrigerant gas with a relatively low temperature passes near the electric motor 21. Therefore, heat environmental of the electric motor 21 is satisfactory.

A first accommodating recess 61b is formed on a part of a back surface 61a of the fixed base plate 61 of the fixed scroll member 41 in the range from the adjacent center portion to the adjacent outer periphery. The first accommodating recess 61b is closed by the cover 11b, thereby defining a discharge chamber 70 as a discharge pressure region between the fixed scroll member 41 and the cover 11b in the housing 11. An outlet 53 is formed in the cover 11b. An external conduit is connected to the discharge chamber 70 through the outlet 53 and leads to a heat exchanger on a high-pressure side in the external refrigerating circuit (not shown).

A discharge hole 61c as a discharge passage is formed in the center of the fixed base plate 61 of the fixed scroll member 41 so as to extend therethrough in a direction of the axis L and interconnects the compression chamber 67 near the center of the fixed base plate 61 with the discharge chamber 70. A discharge valve 55 constituted of a reed valve is arranged at the fixed scroll member 41 in the discharge chamber 70 for opening and closing the discharge hole 61c. A retainer 56 is fixed to the fixed scroll member 41 in the discharge chamber 70 to restrict the opening degree of the discharge valve 55.

When the rotary shaft 13 is rotatively driven by the engine E or the electric motor 21, the movable scroll member 42 orbits around the axis of the fixed scroll member 41 (the axis L of the rotary shaft 13) through the crankshaft 43 in the

compression mechanism 12. At this time, the self-rotation preventing mechanism 68 prevents the movable scroll member 42 from self-rotating while allowing the movable scroll member 42 to orbit around the axis of the fixed scroll member 41.

As the compression chambers 67 are moved radially and inwardly by the orbital movement of the movable scroll member 42 relative to the fixed scroll member 41, the compression chambers 67 reduce in volume. Thereby, the low-pressure refrigerant gas introduced from the suction chamber 69 into the compression chambers 67 is compressed. After compression, the high-pressure refrigerant gas is discharged from the discharge hole 61c into the discharge chamber 70 through the discharge valve 55.

A variable displacement mechanism of the compressor C will be now described. As shown in FIGs. 2 and 3A, a second accommodating recess 61d is formed on the back surface 61a of the fixed base plate 61 of the fixed scroll member 41. The second accommodating recess 61d has a horseshoe shape (an annular shape of which a part is removed therefrom) so as to avoid the first accommodating recess 61b. The opening of the second accommodating recess 61d is closed by the end surface of the cover 11b, thereby defining a valve chamber 45. A valve plate 46 is movably accommodated in the valve chamber 45.

The valve plate 46 has a planar shape and a horseshoe shape so as to

be fitted in the second accommodating recess 61d. In other word, the discharge hole 61c is arranged at the center (a through hole) of the valve plate 46, and the valve plate 46 is formed so as to avoid the discharge hole 61c. An O-ring 47 is attached on the outer circumferential surface of the valve plate 46. The valve plate 46 is slidable relative to the inner circumferential surface of the valve chamber 45 through the O-ring 47.

The valve plate 46 is arranged to divide the valve chamber 45 into a communication chamber 48 on the side of the fixed scroll member 41 and a back pressure chamber 49 on a side of the cover 11b. The O-ring 47 on the valve plate 46 blocks between the communication chamber 48 and the back pressure chamber 49. A valve seat surface 48a having a horseshoe-shape is formed in the fixed base plate 61 in the communication chamber 48 so as to face a plate surface (hereinafter referred to as a front end surface) 46a of the valve plate 46, which has a horseshoe-shape. The valve plate 46 is arranged along the fixed base plate 61 in such a manner that the front end surface 46a of the valve plate 46 is parallel to the back surface 61a of the fixed base plate 61.

A first valve hole 61e is formed in the fixed base plate 61 of the fixed scroll member 41 so as to extent therethrough in the direction of the axis L. One end of the first valve hole 61e is open to the compression chamber 67 in a process of volume reduction, and the other end of the first valve hole 61e is open

to the communication chamber 48 at the valve seat surface 48a of the fixed base plate 61. The first valve hole 61e is plurally provided. Each of the first valve holes 61e interconnects the compression chamber 67 with the communication chamber 48 at a position that is different from each other. The first valve holes 61e communicate with the compression chamber 67 in the process of volume reduction by turns during time when the compression chamber 67 at an initial position of volume reduction that has a maximum volume reduces in volume to a predetermined value (e.g. 20% of the maximum volume).

A second valve hole 61f is formed in the fixed base plate 61 of the fixed scroll member 41 so as to extend therethrough in the direction of the axis L. The second valve hole 61f interconnects the communication chamber 48 with the suction chamber 69. The second valve hole 61f is open to the communication chamber 48 at a position that is different from the first valve holes 61e at the valve seat surface 48a of the fixed base plate 61. In the present preferred embodiment, the first valve holes 61e, the second valve hole 61f and communication chamber 48 constitute a by-pass passage that interconnects the compression chamber 67 in the process of volume reduction with the suction chamber 69.

The valve plate 46 selectively moves between an open position, where the front end surface 46a of the valve plate 46 is separated from the valve seat surface 48a in the communication chamber 48 to simultaneously open the first

valve holes 61e and the second valve hole 61f, and a close position, where the front end surface 46a of the valve plate 46 contacts the valve seat surface 48a to simultaneously close the first valve holes 61e and the second valve hole 61f. The front end surface 46a of the valve plate 46 is provided by a rubber coat 46b, or a seal member, that is applied to the valve plate 46. Therefore, when the valve plate 46 is located at the close position, the front end surface 46a reliably seals the first valve holes 61e and the second valve hole 61f due to elastic deformation of the rubber coat 46b.

An actuator for actuating the valve plate 46 is constituted of an urging spring 57, a control valve 58, and first, second and third passages 71 through 73. The urging spring 57 is arranged in the communication chamber 48. The control valve 58 is constituted of an electromagnetic three-way valve. The first passage 71 interconnects the discharge chamber 70 with the control valve 58. The second passage 72 interconnects the back pressure chamber 49 with the control valve 58. The third passage 73 interconnects the suction chamber 69 with the control valve 58. The control valve 58 is symbolized in FIGs. 1, 3A and 3B for easy understanding. The first and second passages 71 and 72 correspond to a first control passage, and the second and third passages 72 and 73 correspond to a second control passage.

A plurality of the urging spring 57 is arranged between the valve seat

surface 48a of the fixed base plate 61 and the front end surface 46a of the valve plate 46 so as to avoid the openings of the first and second valve holes 61e and 61f. The valve plate 46 is urged by the spring force of the urging spring 57 in a direction in which the front end surface 46a is separated from the valve seat surface 48a. The first, second and third passages 71 through 73 respectively communicate with first, second and third ports 58a, 58b and 58c of the control valve 58.

In the present preferred embodiment, the first passage 71, an internal passage of the control valve 58 and the second passage 72 constitute a control passage that interconnects the back pressure chamber 49 with the discharge chamber 70. The control valve 58 opens and closes the control passage based on an external command. Namely, the communication with the second passage 72 is switched between the first and third passages 71 and 73 by energizing and de-energizing a solenoid 58d based on the external command. In other word, the communication with the back pressure chamber 49 is switched between the suction chamber 69 and the discharge chamber 70 by energizing and de-energizing the solenoid 58d.

For example, as shown in FIG. 3B, when the solenoid 58d is de-energized, the first passage 71 communicates with the second passage 72 through the control valve 58. Therefore, the high-pressure refrigerant gas in the

discharge chamber 70 is discharged into the back pressure chamber 49 through the first passage 71, the control valve 58 and the second passage 72. Since the third passage 73 is closed by the control valve 58 in this state, the refrigerant gas in the back pressure chamber 49 is not discharged into the suction chamber 69. Consequently, the pressure in the back pressure chamber 49 increases, and the valve plate 46 moves to the close position against the spring force of the urging spring 57 and force based on the pressure in the communication chamber 48 so that the first and second valve holes 61e and 61f are closed.

In a state where the first and second valve holes 61e and 61f are closed, the compression chamber 67 in the process of volume reduction does not communicate with the suction chamber 69. Also, the compression chamber 67 substantially completely compresses the refrigerant gas so that the displacement of the compression mechanism 12 becomes the maximum. For example, when the engine E is selected to drive the compression mechanism 12, the compression mechanism 12 performs the maximum displacement. Therefore, even though the rotational speed of the rotary shaft 13 is relatively small due to an idling state of the engine E, the compression mechanism 12 ensures a large amount of the discharged refrigerant gas per unit time, that is, the compression mechanism 12 performs relatively high cooling capacity.

Also, as shown in FIG. 3A, when the solenoid 58d is energized, the

second passage 72 communicates with the third passage 73 through the control valve 58. Therefore, the refrigerant gas in the back pressure chamber 49 is discharged into the suction chamber 69 through the second passage 72, the control valve 58 and the third passage 73. Since the first passage 71 is closed by the control valve 58 in this state, the high-pressure refrigerant gas in the discharge chamber 70 is not discharged into the back pressure chamber 49. Consequently, the pressure in the back pressure chamber 49 falls, and the valve plate 46 moves to the open position by the spring force of the urging spring 57 and force based on the pressure in the communication chamber 48 so that the first and second valve holes 61e and 61f are opened.

In a state where the first and second valve holes 61e and 61f are opened, the compression chamber 67 in the process of volume reduction continuously communicates with the suction chamber 69 through any one of the first valve holes 61e and through the communication chamber 48 and the second valve hole 61f until the compression chamber 67 reduces in volume to the predetermined value. Therefore, the compression chamber 67 does not completely compress the refrigerant gas so that the displacement of the compression mechanism 12 is reduced from the maximum. For example, when the electric motor 21 is selected to drive the compression mechanism 12, the displacement of the compression mechanism 12 is reduced from the maximum. As the displacement of the compression mechanism 12 is reduced, torque required for driving the

compression mechanism 12 becomes small. Therefore, the compressor C is downsized by reducing the size of electric motor 21.

In the present preferred embodiment, following advantageous effects are obtained.

(1) The opening and closing of the by-pass passages 48, 61e and 61f, that is, the variation of the displacement of the compressor C, is performed by contacting the front end surface 46a of the valve plate 46 with the valve seat surface 48a and separating the front end surface 46a of the valve plate 46 from the valve seat surface 48a. Therefore, in a state where the valve plate 46 is located at the close position, the contact of the front end surface 46a of the valve plate 46 with the valve seat surface 48a seals the by-pass passages 48, 61e and 61f. For example, in Japanese Unexamined Patent Publication No. 2001-32787, a valve portion (a column) of a spool opens and closes a port that is open at an inner circumferential surface of a cylinder (an inner surface of the cylinder). In comparison to this structure, closely contact between the front end surface 46a of the valve plate 46 and the valve seat surface 48a can be easily enhanced without inhibiting mobility of the valve plate 46. Therefore, sealing the by-pass passages 48, 61e and 61f in a state where the valve plate 46 is located at the close position can be ensured. Also, deterioration of performance of the compress C due to the leakage of the refrigerant gas from the by-pass passages 48, 61e and 61f is

suppressed.

(2) The by-pass passages 48, 61e and 61f are formed so as to continuously interconnect the compression chamber 67 with the suction chamber 69 until the compression chamber 67 in the process of volume reduction reduces in volume to the predetermined value in a state where the valve plate 46 is located at the open position. Namely, when the valve plate 46 is located at the open position, the compression chamber 67 does not completely compress until the compression chamber 67 reduces in volume to the predetermined value after the start of volume reduction. Accordingly, for example, in comparison to a variable displacement mechanism that changes the displacement of the compressor to a relatively small displacement by interconnecting a compression chamber with a suction pressure region after the compression chamber compresses until the compression chamber reduces in volume to a predetermined value, power loss of the compressor C caused due to re-compression for the refrigerant gas, that is, due to useless compression work, is suppressed.

(3) The first valve holes 61e partially constitute the by-pass passages 48, 61e and 61f on an upstream side (a side of the compression chamber 67). The first valve hole 61e is plurally provided. Each of the first valve holes 61e interconnects the compression chamber 67 with the communication chamber 48

at a position that is different from each other. The different portions of the front end surface 46a of the valve plate 46 simultaneously opens and closes a plurality of the first valve holes 61e. Therefore, the above described continuous communication between the compression chamber 67 in the process of volume reduction and the suction chamber 69 can be easily achieved without any complicated structure.

Namely, for example, it is necessary to utilize a plurality of spool valves to open and close a plurality of valve holes due to interspersion of a plurality of the valve holes as disclosed in Japanese Unexamined Patent Publication No. 2001-32787. However, according to the valve plate 46 utilized in the present preferred embodiment, simple structure, in which the valve plate 46 having a size in accordance with the interspersion of a plurality of the first valve holes 61e is utilized, preferably deals with interspersion of a plurality of the first valve holes 61e.

(4) The valve plate 46 simultaneously opens and closes the second valve 61f that partially constitutes the by-pass passages 48, 61e and 61f on the side of the suction chamber 69 relative to the communication chamber 48. Therefore, the first and second valve holes 61e and 61f are simultaneously closed in a state where the valve plate 46 is located at the close position, and sealing the by-pass passages 48, 61e and 61f can be ensured further.

(5) The valve plate 46 is arranged along the fixed base plate 61 of the fixed scroll member 41. Even though the compressor C includes the variable displacement mechanism, the compressor C is not lengthened in a direction of the axis L due to such arrangement of the valve plate 46. In other word, by utilizing the valve plate 46 (a plate-shaped body) as an open-close means for opening and closing the by-pass passages 48, 61e and 61f, compact design to arrange the open-close means along the fixed base plate 61 of the fixed scroll member 41 is achieved.

Particularly, the compressor C is a hybrid compressor that is selectively driven by one of the power from the engine E through the power transmission mechanism 22 arranged at the housing 11 and the power from the electric motor 21 installed in the housing 11. Therefore, the compressor C tends to be large-sized by including the power transmission mechanism 22 and the electric motor 21. When a compact variable displacement mechanism is utilized in the compressor C, increasing size of the compressor C is effectively suppressed.

(6) The valve plate 46 has an incomplete annular shape that is an annular shape of which a part is removed therefrom. The discharge hole 61c is arranged at the center (the through hole) of the valve plate 46 for discharging the compressed refrigerant gas from the compression chamber 67 near the center of

the fixed base plate 61 with the discharge chamber 70. As mentioned above, since the discharge hole 61c is formed at the center of the valve plate 46 that is not utilized for opening and closing the first and second valve holes 61e and 61f, the compression chamber 67 near the center of the fixed base plate 61 can be interconnected with the discharge chamber 70 at a minimum distance. Therefore, the refrigerant gas can smoothly flow from the compression chamber 67 near the center of the fixed base plate 61 to the discharge chamber 70 so that the compressor C is prevented from deteriorating efficiency of the compressor C due to pressure loss based on conduit resistance between the compression chamber 67 and discharge chamber 70.

(7) The rubber coat 46b is provided at the front end surface 46a of the valve plate 46 for sealing the by-pass passages 48, 61e and 61f in a state where the valve plate 46 is located at the close position. Therefore, sealing the by-pass passages 48, 61e and 61f in a state where the valve plate 46 is located at the close position can be ensured further. Namely, the valve plate 46 is utilized as the open-close means for opening and closing the by-pass passages 48, 61e and 61f, and the structure, in which the front end surface 46a of the valve plate 46 contacts the valve seat surface 48a and is separated from the valve seat surface 48a, is utilized. Therefore, it is possible to arrange the rubber coat 46b for improving the seal of the by-pass passages 48, 61e and 61f in a state where the valve plate 46 is located at the close position without inhibiting the mobility of the

valve plate 46

Following alternative embodiments may be practiced according to the present invention.

In the above preferred embodiment, only the single valve plate 46 is provided. Therefore, the displacement of the compressor C is switched only between the maximum displacement by locating the valve plate 46 at the close position and the minimum displacement by locating the valve plate 46 at the open position. The valve plate 46 may be divided into a plurality of parts, and the displacement of the compressor C may be switched among more than three displacements.

Namely, for example, the valve plate 46 in the above preferred embodiment is divided into first and second parts. The first part of the valve plate 46 opens and closes a group of the first valve holes 61e that interconnect the suction chamber 69 with the compression chamber 67 in the process of volume reduction whose volume ranges from the maximum volume to a certain value (larger than the predetermined value). The second part of the valve plate 46 opens and closes another group of the first valve holes 61e that interconnect the suction chamber 69 with the compression chamber 67 in the process of volume reduction whose volume ranges from the certain value to the predetermined

value. In this case, when the first and second parts of the valve plate 46 are located at the close position, the displacement of the compressor C becomes the maximum. When the first and second parts of the valve plate 46 are located at the open position, the displacement of the compressor C becomes the minimum. When the first and second parts of the valve plate 46 are respectively located at the open position and the close position, the displacement of the compressor C becomes an intermediate displacement between the maximum and the minimum.

In the above preferred embodiment, the valve plate 46 has an annular shape of which a part is removed therefrom so as to avoid the discharge valve 55 and the base of the retainer 56 as shown in FIG. 2. However, when a short discharge valve 55 and a short retainer 56 are utilized and the bases of the discharge valve 55 and the retainer 56 are located closer to the center of the fixed scroll member 41 (the side of the discharge hole 61c), the valve plate 46 may be formed in a complete annular shape so as to surround the discharge valve 55 and the retainer 56. In this case, the same advantageous effect is obtained as mentioned in paragraph (6) according to the above preferred embodiment.

In the above preferred embodiment, the by-pass passages 48, 61e and 61f are formed so as to continuously interconnect the compression chamber 67 with the suction chamber 69 until the compression chamber 67 in the process of volume reduction reduces in volume to the predetermined value in a state where

the valve plate 46 is located at the open position. However, the by-pass passages 48, 61e and 61f are not limited to the above preferred embodiment and may be formed so as to interconnect the compression chamber 67 with the suction pressure region after the compression chamber 67 has compressed to reduce in volume to a predetermined value. This manner reduces the number of the first valve holes 61e and simplifies the structure of the by-pass passage.

In the above preferred embodiment, the valve plate 46 moves between the open position and the close position by regulating the pressure in the back pressure chamber 49 by the control valve 58. The valve plate 46 may be formed to move between the open position and the close position by directly actuating the valve plate 46 by an electromagnetic actuator.

Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.